LAGRANGIAN FORMULATION OF THE FLUID MECHANIC PROBLEMS INCLUDING FREE-SURFACE AND BREAKING WAVES

S. R. Idelsohn[a b], F. Del Pin[a] , N. Calvo[a], and E. Oñate[b]

[a]International Center for Computational Methods in Engineering (CIMEC)
INTEC (CONICET-Universidad Nacional del Litoral)
Guemes 3450, 3000 Santa Fe, Argentina
sergio@ceride.gov.ar

[b]International Center for Numerical Methods in Engineering (CIMNE)
Edificio C1, Campus Nord
Universidad Politécnica de Cataluña
08034 Barcelona, Spain
onate@cimne.upc.es

Over the last twenty years, computer simulation of incompressible fluid flow has been based on the Eulerian formulation of the fluid mechanics equations. However, it is still difficult to analyze problems in which the shape of the interface changes continuously or in fluid-structure interactions with free-surfaces where complicated contact problems are involved.

More recently, *Particle Methods* in which each fluid particle is followed in a Lagrangian manner have been used [1]. The first ideas on this approach were proposed by Monaghan [1] for the treatment of astrophysical hydrodynamic problems with the so called *Smooth Particle Hydrodynamics Method* (SPH). Kernel approximations are used in the SPH method to interpolate the unknowns.

On the other hand, a family of methods called *Meshless Methods* have been developed both for structural and fluid mechanics problems. All these methods use the idea of a polynomial interpolant that fits a number of points minimizing the distance between the interpolated function and the value of the unknown point. These ideas were proposed first by Nayroles *et al.*, they were later used in structural mechanics by Belytschko *et al.* and in fluid mechanics problems by Oñate *et al.*. In a previous paper the authors presented the numerical solution for the fluid mechanics equations using a Lagrangian formulation and a meshless method called the Finite Point Method. Lately, the meshless ideas were generalized to take into account the finite element type approximations in order to obtain the same computing time in mesh generation as in the evaluation of the meshless connectivities . This method was called the Meshless Finite Element Method (MFEM) [2] and uses the Extended Delaunay Tessellation to build the mesh in a computing time which is linear with the number of nodal points.

In this paper new ideas and results for the solution of a particle method in the field of Fluid-Structure Interaction (FSI) using the Meshless Finite Element Method are presented [3]. Free-surfaces as well as breaking waves are solved in a natural way without including any additional boundary condition.

References

[1] R.A. Gingold and J.J. Monaghan, *Smoothed particle hydrodynamics, theory and application to non-spherical stars*, Mon. Nat. Roy. Astr. Soc., 181, (1997), 375–389.
[2] S.R. Idelsohn, E. Oñate, N. Calvo and F. Del Pin, *The meshless finite element method*, In press in Int. J. for Numerical Methods in Engineering, (2002).
[3] S.R. Idelsohn, E. Oñate and F. Del Pin, *A lagrangian meshless finite element method applied to fluid-strucrure interaction problems*, In press in Computer & Structures, (2002).